EXAMPLE OF A PROCEDURE FOR PERFORMING LOAD TESTS ON STANDARD CABLEWAY STRUCTURES

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1. **Basis for Test Load**.

Three load factors are considered in the design of U.S. Geological Survey cableway structures (TWRI-3A21, by C.R. Wagner, 1995).

A. *Dead Load.* The weight of the cable which can be the limiting load in the case of long span widths.

B. *Concentrated Load*. The weight carried by the cable car which is the sum of the weights of a standard cable car (170 pounds), a sounding reel (50 pounds), two 200-pound field personnel (400 pounds), and the breaking strength of a 0.125-inch diameter sounding cable (1,600 pounds). This combined weight results in a concentrated load approximating a 2,250-pound design load for standard cable car installations.

C. *Wind and Ice Load*. The stress created by wind blowing against the cable and/or the weight of ice accumulation on the cable.

Among these factors, the "concentrated load" is of primary concern when the cableway is in use. It is the "concentrated load" that is simulated during testing. Based on the configuration described above, a test load of 2,250 pounds is recommended for standard installations. This test load is easily achieved with portable load-test devices incorporating either a collapsible bladder or a rigid tank.

2. **Cableway Components Tested**.

During a load test, the entire cableway structure is stressed with a concentrated load. The application of this load to the suspended cable will provide a static test combining the concentrated hanging load plus the dead load of the cable to stress the holding capacity of anchorages and attendant hardware. To maximize effectiveness, load tests should be scheduled during critical periods of high soil moisture.

The static test does not apply a load to the suspended cable at a downstream angle. Therefore, this test does not add a tipping moment and the associated shear stresses to the A-frames, towers, support trees, or rock anchors that would be present in the cases of debris snagging the sounding cable during high flow measuring or sampling.

The static test will challenge:

A. Tensile (breaking) strength of the suspended cable (wire, rope, or structural strand).

B. Support strength of A-frames, or towers, and their saddle blocks and footings under a compression load.

C. Shear strength of bolts attaching sheaves to support trees and rock anchors directly attached to the cable without an intervening support structure.

D. Holding strength of cable clips at turn backs.

E. Shear and tensile strengths of U-bars and turnbuckles at anchors.

F. Holding capacity of the anchor structures relative to their mass and active and passive resistance to the soil in contact with the anchors at times when soil moisture is high.

G. Tensile (breaking) strength of backstays and their components.

3. **Pre-Test Checks, Measurements, and Markings**.

The purpose of pre-test checks, measurements, and markings is to establish a baseline against which post-test checks and measurements can be compared to assess the strength of questionable cableway structures. Visual pre-test checks are designed to determine if the structure will likely support the test load. Successful completion of this test provides a load factor of 1.0 and is not expected to result in permanent changes to an acceptable cableway structure.

Prior to applying a test load, a number of checks, measurements, and markings must be made. These steps must be taken to determine if the potential for catastrophic failure of a cableway component is obvious from visual inspection. This inspection helps to ensure that a failure of the cableway can be avoided entirely by aborting the test and condemning the structure. It also makes the test crew aware of potential problems so that their safety is not compromised. These checks, measurements, and markings also make it possible to determine if movement within the system of the structure's components has occurred as a result of test-load stress. The marking is accomplished by the application of spray paint at the locations indicated below.

A. *Procedure.*

(1) *Pre-Test Checks.*

(a) Inspect the cable support structures to ensure that they are plumb and sitting firmly and squarely on their footings.

(b) Inspect the support structure footings to ensure that they are in good condition and appear to be capable of supporting the test load.

(c) Inspect the main cable socket and/or cable clip connections to ensure that they are free of obvious stress fractures and that the cable clips are properly torqued.

(d) Inspect the tie-back cables to ensure that socket and/or cable clip connections are free of obvious stress fractures, cable clips are properly torqued, and the connection to the support structure is sound.

(e) Inspect U-bars, rock anchors, and turnbuckles to ensure that they are free from obvious stress fractures and excessive rust or corrosion.

(f) Inspect saddle blocks to ensure that the cable is not bent too sharply and not in contact with the bolts holding the block in place.

(2) *Pre-Test Measurements.*

(a) Determine the correct unloaded sag.

(b) Measure the existing unloaded sag in the cable and adjust it to the correct design sag (but never more than 2 percent of the span width).

(c) Establish stable reference points on each bank and measure the distance to the top of each U-bar, to at least one corner of each anchor, and to the base of each leg of the support structures.

(d) Measure the distance from each U-bar to the bases of the associated support structure.

(e) Run levels to anchors, footings, and to the lowest elevation of the cable so that the loaded sag can be monitored during the test.

(3) *Pre-Test Markings.*

(a) Mark the U-bars and rock anchors at the concrete or rock-to-steel interface.

(b) Mark cable clips, sockets, and turnbuckles at cable-to-hardware contacts.

(c) Mark the bases of support structures at points of contact with their footing and around pins or bolts securing them to the footings.

4. **Application of Test Load to the Structure**.

If there is no obvious potential for catastrophic failure of any cableway component after all pre-test checks, measurements, and markings have been completed, the structure is ready for load testing. During the test, the safety of all test crew members must not be compromised. Develop a safety plan that will keep all personnel out of harm's way during the test.

A. *Procedure*.

(1) *Setup.*

(a) If a collapsible bladder is used, the cargo net to contain and support it should be placed on the bank from which the test will be initiated and as near to the support structure and/or anchor as possible.

(b) The bladder is then laid out flat on the net with the dump valve and valve trip line in place.

(c) If a rigid tank is to be used, steps 1 and 2 can be combined because the cargo net is not needed to contain the load.

(d) With the load container in position below the cableway, the carriage should be placed on the cable and held in position above the container using a tie-back line. This line attaches the carriage to the adjacent anchor or other nearby fixed object (e.g., tree, A-frame, etc.) until the load container is lifted free of the ground after filling. (The tie-back line will be cut to allow the load assembly to travel along the cable to the position of maximum sag.)

(e) All tackle from the carriage to the load container should be attached to allow lifting the load with a 12-volt electric winch.

(f) A control line should be attached to the carriage to enable control of the loaded container assembly as it travels along the cable to the position of maximum sag. (**Caution**: Be prepared to safely handle the considerable weight that will be encountered.)

(h) After attaching all necessary tackle, the load container is filled with stream water using an electric, submersible pump and generator combination or a gasoline-powered pump. When filling the load container to achieve the desired test load, the filling process must be monitored to avoid overloading the structure. The volume of stream water pumped into the load container must be measured or a dynamometer must be placed above the load container to monitor the water weight (water weighs 8.33 pounds per gallon).

(2) Application of Test Load.

(a) Once the load container is filled with the correct amount of water to achieve the desired test load, the load can be placed on the cableway by winching it off the ground until the cable freely supports it. The load must be high enough to clear the stream surface when allowed to travel along the cable to the position of maximum sag. (**Note**: Experience has proven that in most cases

the load container must be lifted into place while partially loaded and filling completed near the bank or at the position of maximum sag. This is due to the limitations of the relatively small, 12-volt electric winch powered by an independent deep-cycle battery without benefit of recharge.)

(b) At this point all test crew members should remain clear of the cableway structure and out of the paths of supports and cable while carefully watching anchors and attachment hardware for any signs of movement or potential failure.

(c) If there is no apparent sign of potential failure with the test load suspended from the cable near one end of the cableway structure, tension can be applied to the control line attached to the carriage to prevent movement of the carriage when the tie-back line is cut. The tie-back line is cut and the load is allowed to travel along the cable in a controlled manner to the position of maximum sag. (**Caution**: Be prepared to safely handle the considerable weight that will be encountered.)

(3) *Removal of the Test Load.*

(a) After the load is allowed to settle at or near the position of maximum sag, it should remain in place for 10 minutes while the loaded sag is measured. Run levels to the control points.

(b) At the end of the 10-minute period and after the loaded sag is determined, the dump valve is tripped to release the water load into the stream.

(c) After the water load is removed, the load container is retrieved with the control line.

(d) The load container assembly is lowered to the ground and broken down for transport by reversing the procedure described in the load-test setup.

5. **Post-Test Checks and Measurements**.

After the test load has been applied and removed from the cableway, careful post-test checks and measurements must be made to determine if displacement of anchors or movement of the cable relative to hardware components occurred as a result of the load testing. If measurable displacement or movement is detected, the cableway has failed the load test and must be taken out of service.

A. *Procedure.*

(1) *Post-Test Checks.*

(a) Inspect the cable support structures to ensure that they are still plumb and sitting firmly and squarely on their footings.

(b) Inspect the support structure footings to ensure that they are still in good condition and appear to be capable of supporting the maximum concentrated load.

(c) Inspect the main cable socket and/or cable clip connections to ensure that they are free of obvious stress fractures.

(d) Inspect the tie-back cables to ensure that socket and/or cable clip connections are free of obvious stress fractures.

(e) Inspect U-bars, rock anchors, and turnbuckles to ensure that they are free of stress fractures or deformation.

(f) Inspect the cable at saddle blocks to ensure that it is not bent too sharply or in contact with the bolts holding the block in place.

(g) Inspect marks on U-bars and rock anchors at the concrete or rock-to-steel interface to ensure that no displacement has occurred.

(h) Inspect marks on cable clips, sockets, and turnbuckles at cable-to- hardware contacts to ensure that no displacement has occurred.

(i) Inspect marks at the bases of support structures at points of contact with their footings and around pins or bolts securing them to the footings to ensure that no displacement has occurred.

(j) Pay particular attention to any deformation of U-bars and other hardware components.

(2) *Post-Test Measurements.*

(a) Measure the unloaded sag in the cable to determine if anchor movement and/or cable stretch has occurred as a result of the test. (**Note:** Re-adjust the sag to the design sag only if it can be attributed to cable stretch.)

(b) Measure from the stable reference points on each bank to the top of each U-bar, to the corners of the anchors, and to the base of each leg of the support structures that were measured before the load test.

(c) Measure the distance from each U-bar to the bases of the associated support structures.

(d) Run levels to anchors, footings, and the lowest elevation of the cable to determine if movement of cableway components occurred during the load test.

6. **Suggested Equipment Necessary for Load Testing of Cableways**.

A. Rigid tank or collapsible bladder.

B. Cargo net (if bladder is used).

C. 12-volt electric winch capable of lifting the test load.

D. 12-volt deep-cycle battery (to power winch).

E. Gasoline or electric pump.

F. Gasoline-powered electric generator (if electric pump is used).

G. Carriage simulating the sheave section at the top of a cable car to support the load and carry it on the cable.

H. Blocks, cable, and hardware to assemble a block and tackle rig for lifting the loaded container during or after filling.

I. Bucket of known volume and stopwatch to measure the flow rate from the pump so that the volume of water delivered to the bladder can be measured (if a rigid tank is used, it should be marked to indicate the volume required to provide the necessary weight for the test).

J. Nylon line (0.5 inch) with snap shackle for control line (length must be greater than that needed to reach the low point of the cable near mid-span).

K. Nylon line with snap shackles for trip line to control dump valve (length must be greater than that needed to reach the low point of the cable near mid-span).

L. Level, level rod, and steel tapes.

M. Surveyor stakes, nails, and hammer.

N. Spray paint for marking hardware, etc.

O. One-wheel game carrier and packboards to transport collapsible bladder and associated equipment to test site (the rigid tank is normally used only at sites with vehicle access).

P. Life vests and flotation ring.

Q. Hard hats.

R. Cellular phone or adequate radio on site during the test to communicate with emergency-care providers should an injury or accident occur.

S. First-aid equipment.

T. Personnel required (five)--Instrument operator/sag observer, rod man/anchor observer (near bank), rod man/anchor observer (far bank), pump and control-line operator, and dump-valve trip-line operator.

U. One handheld radio per crew member for intra-crew communication during the load test.